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An invited talk

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Attaining the optimum glass performances by surface redox reaction – A new way towards advanced glasses for energy technology

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We present our new approaches for creating functional surface layers on the polyvalent ion containing glasses. The modified layers are classified into two groups in terms of chemical nature and structural order. One is the crystalline layer enriched in alkaline earth oxides, and the other is the amorphous layer enriched in silica. The crystalline layer is obtained by subjecting the glasses to oxidation process at the glass transition temperature. During this process, polyvalent ions are transformed from low to high valence state, and this causes electron holes to migrate from the glass surface towards the interior. Therefore, the network modifying ions must diffuse from the interior towards the surface, i.e., outward diffusion occurs. At the surface, the modifying cations react with oxygen ions to form a crystalline layer that enhances the high-temperature stability of heat-insulating glasses. As a mirror effect of the outward diffusion, the inward diffusion can also be induced by subjecting the glass to a reduction process, which leads to formation of an amorphous silica-rich layer. The formation of this layer can greatly contribute to improving physical and chemical functions of glassy materials. In general, both the direction and the extent of the diffusion are controllable, and hence, the surface layers can be tailored. Furthermore, we have revealed the kinetic and thermodynamic mechanisms of formation of both the crystalline and amorphous layers. Very recently, we have made it possible simultaneously to induce the quantum cutting effect and improve the glass surface by doping conventional glasses with rare earth metals and subsequently performing thermal reduction. This finding could likely make the glass act as an ideal substrate material for solar cells.

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